HARRINGTON & CORTELYOU, INC.
A Burns & McDonnell Company

Building Better Box Beam Bridges

The State of the Practice of

Precast/Prestressed Adjacent Box Beam Bridges

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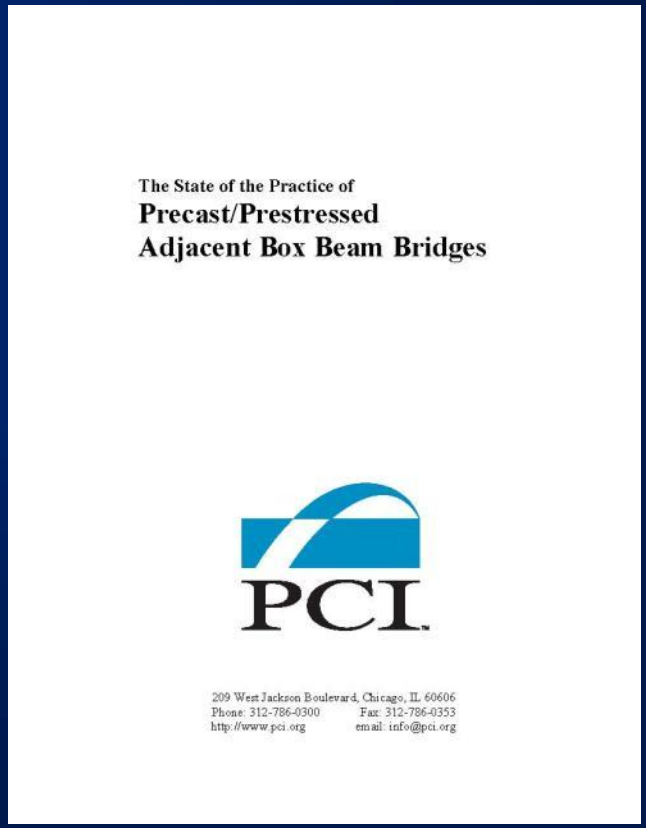
Report Focus

1. Describe the state of the practice.
2. Report on lessons learned.
3. Provide guidelines for better performance.



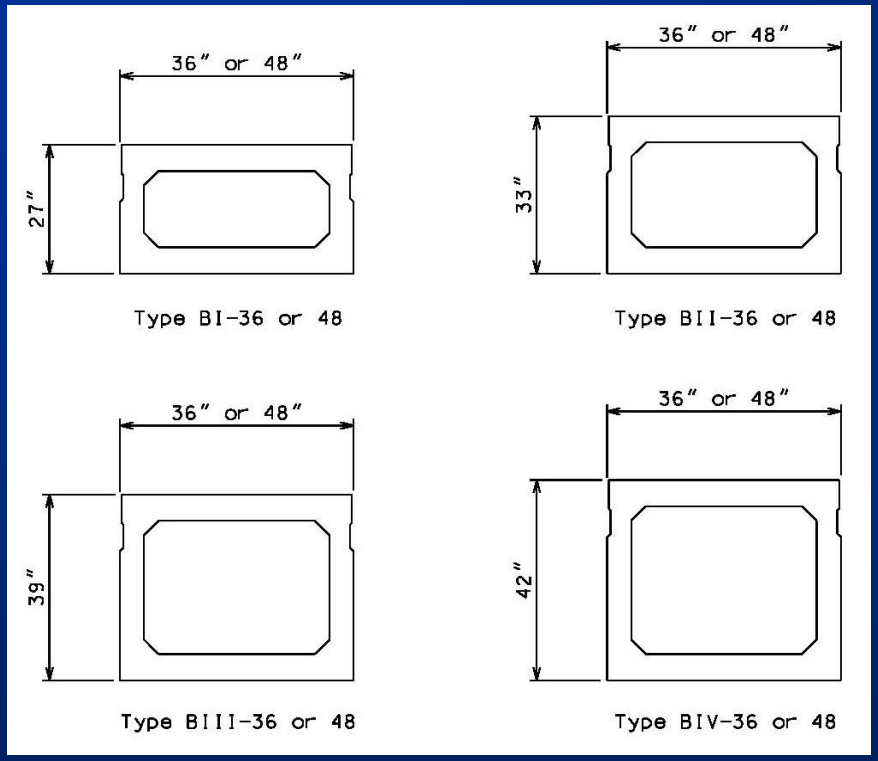
Issues

Leaking Joints

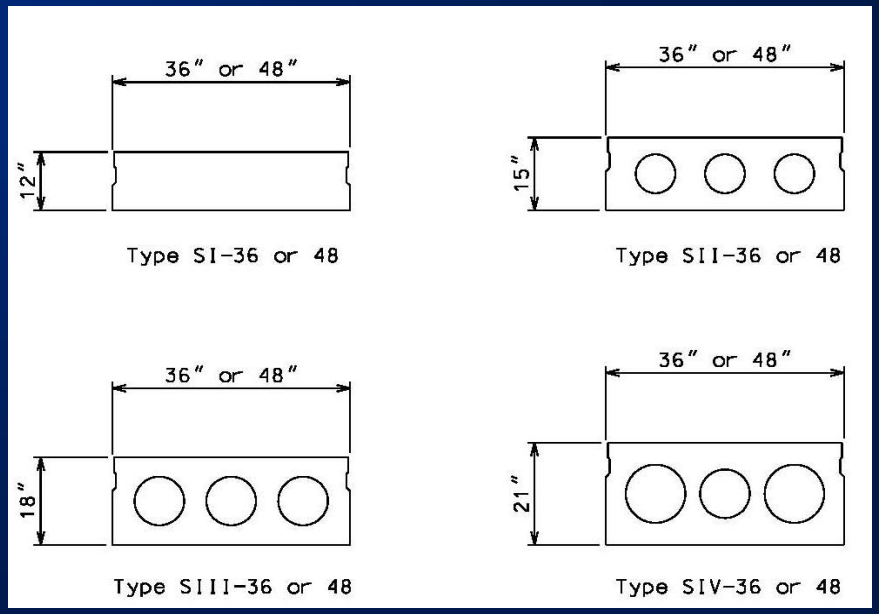
Reflective Deck Cracking

Adjacent Member Bridges

Types of Sections



AASHTO Box Beams



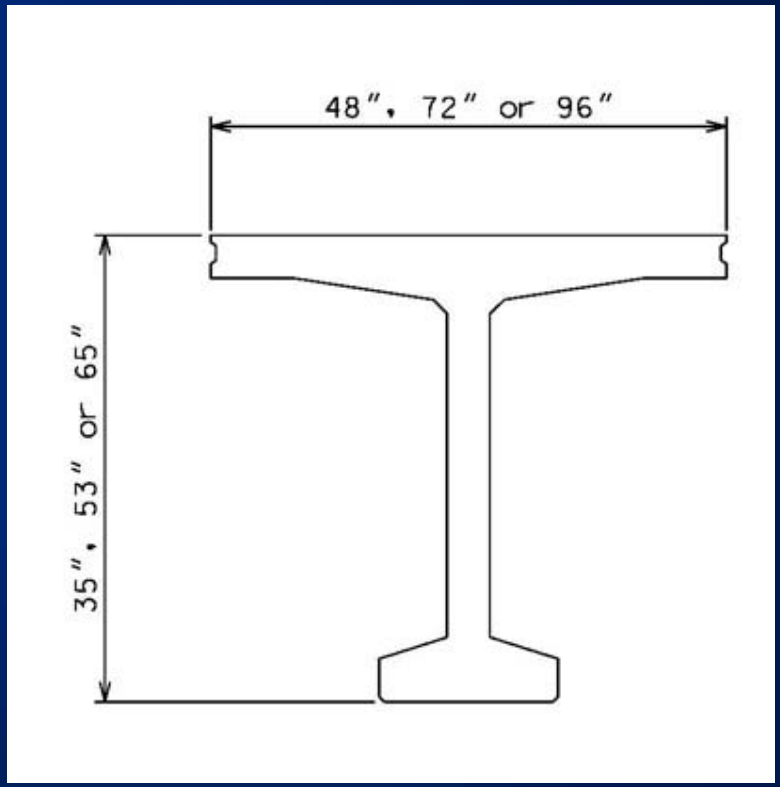
AASHTO Slab Beams

Types of Sections

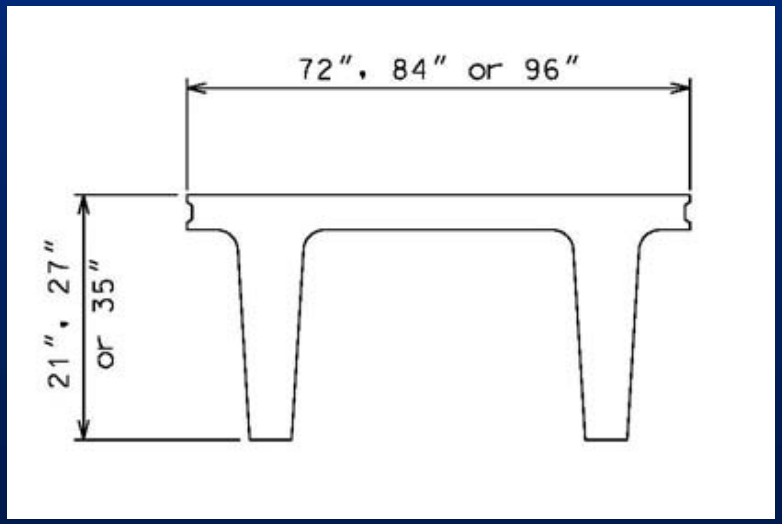
Box Beams

Slab Beams

Types of Sections



Deck Bulb Tees

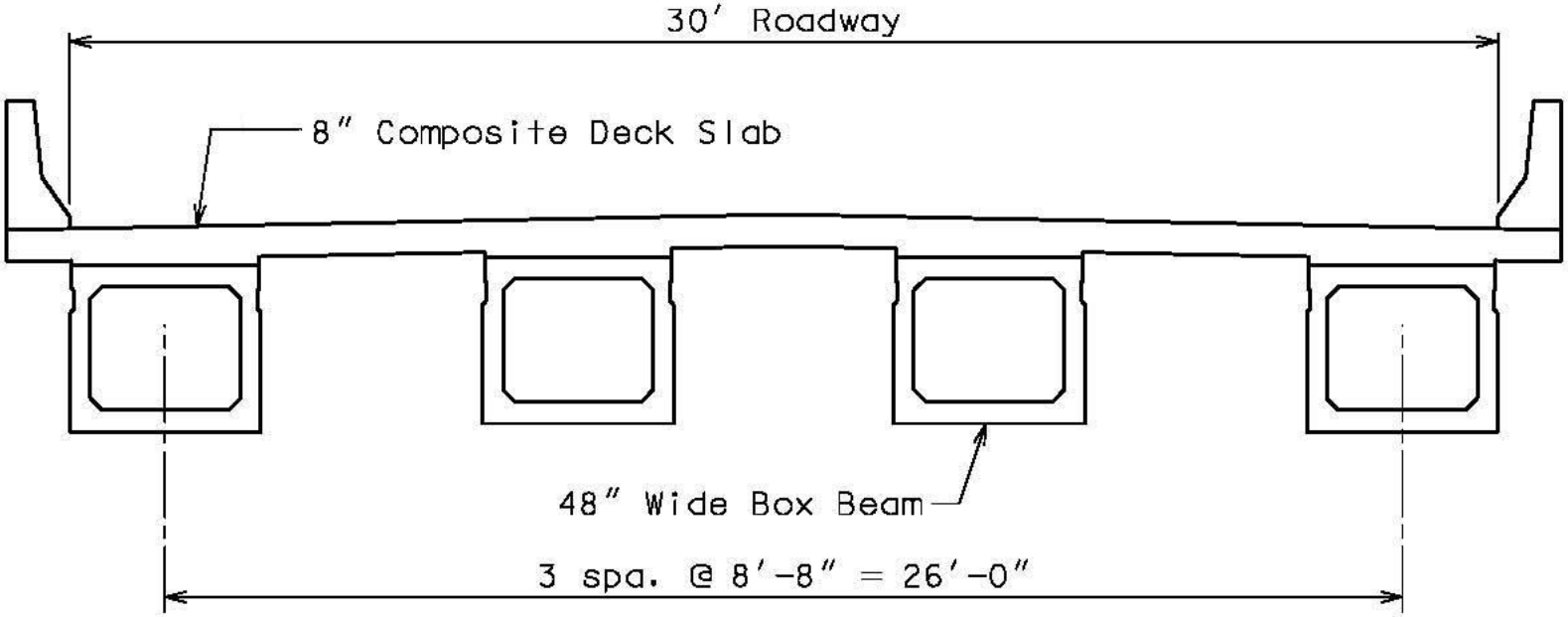


Double Tees

Box Beam Bridges

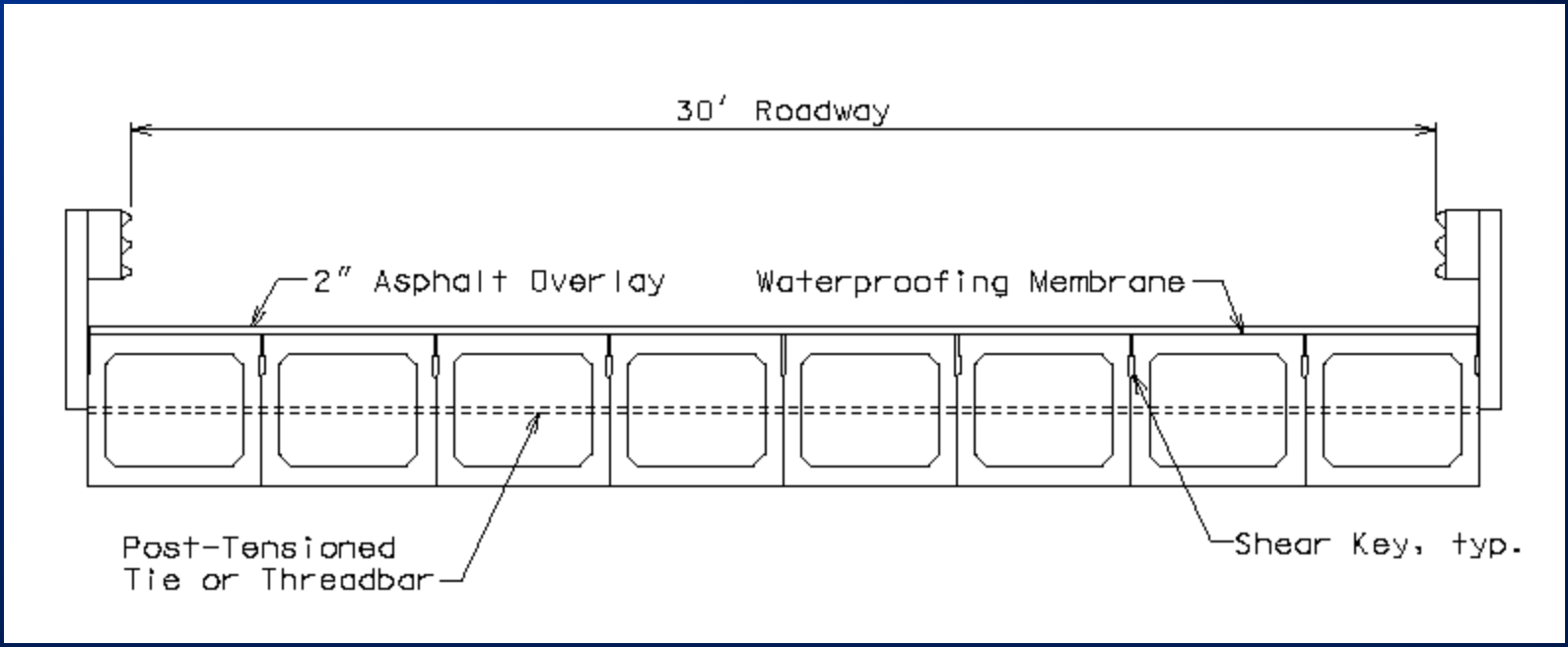
- 50,000 adjacent box bridges (more than 8%)
- 9,000 spread box bridges
- 60 Years

Spread Box Beam Bridges



NOT considered adjacent member bridges

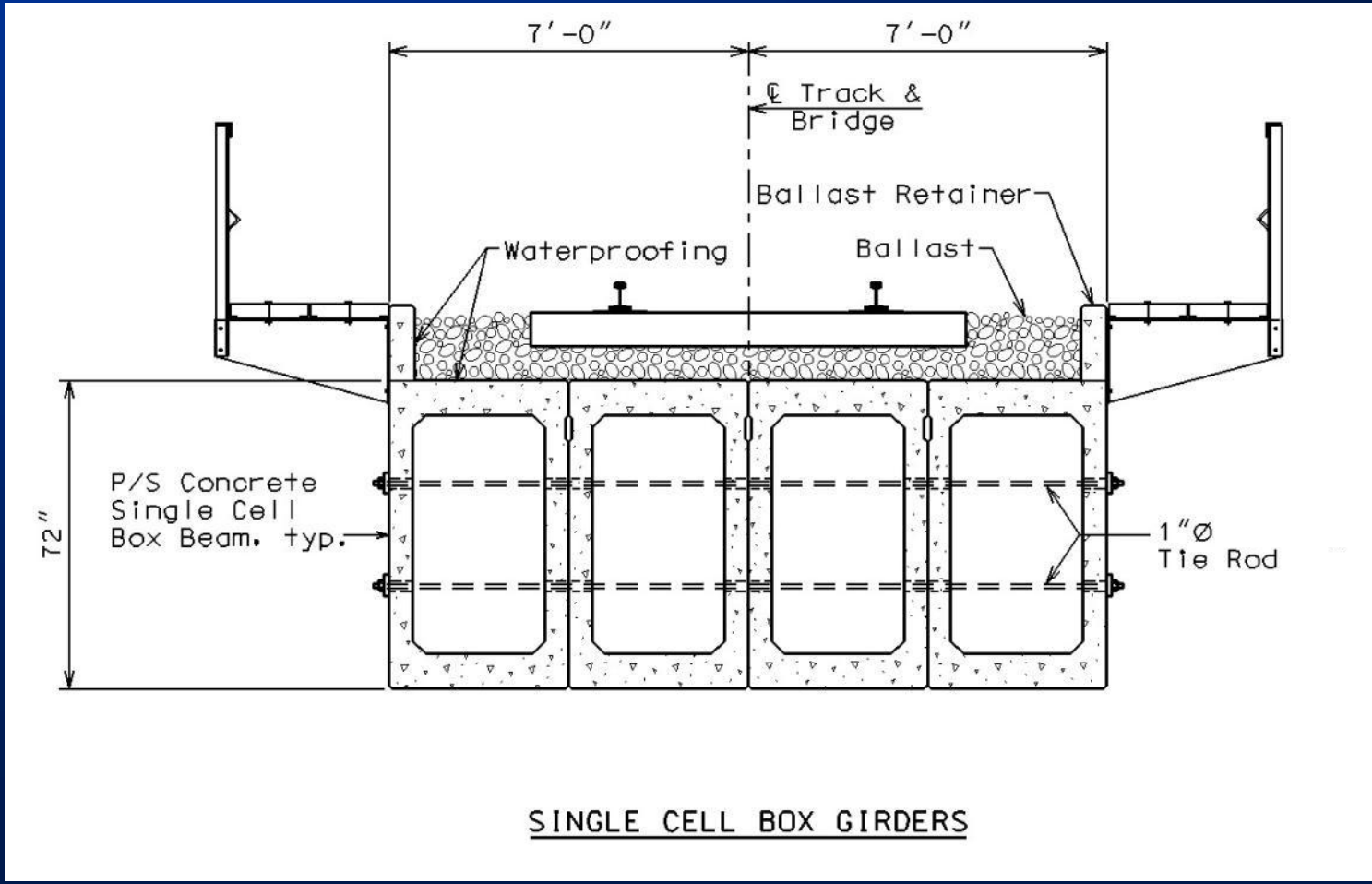
Non-Composite Superstructure



Non-Composite Superstructure

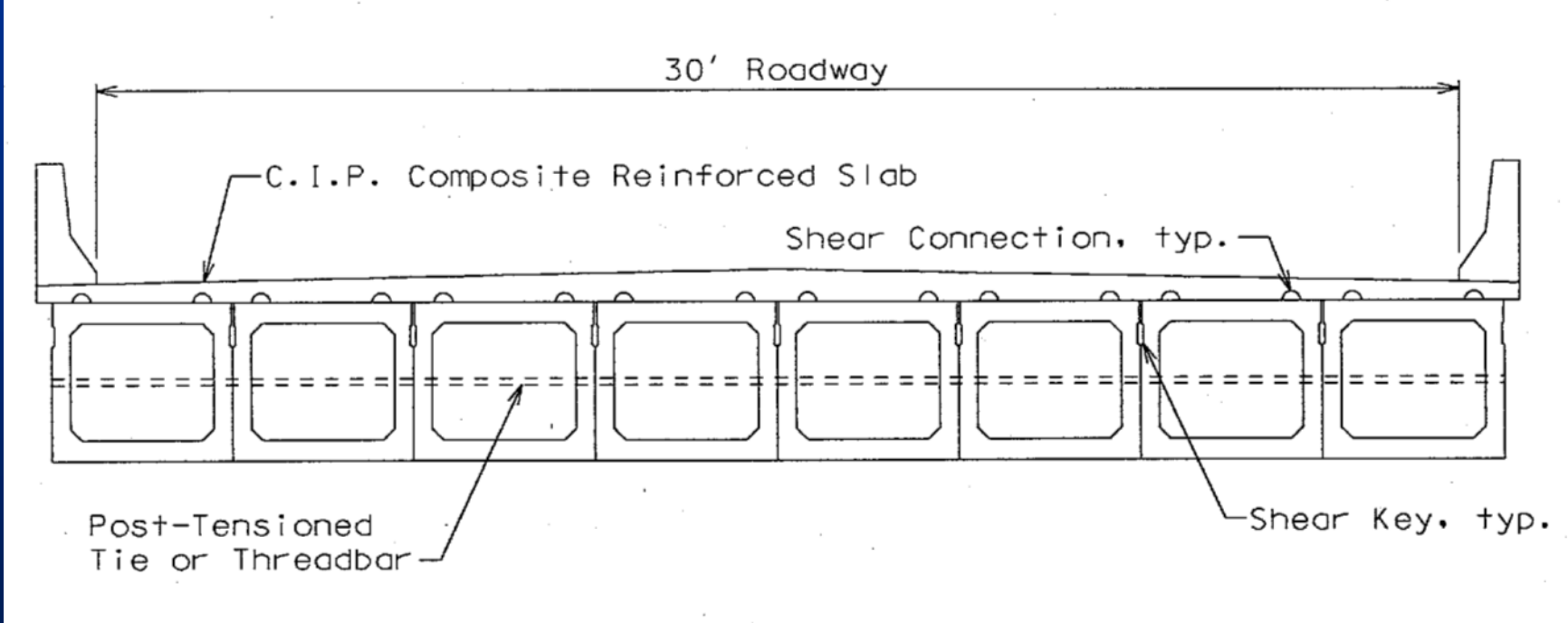
Non-Composite Superstructure

Non-Composite Superstructure



Non-Composite Superstructure

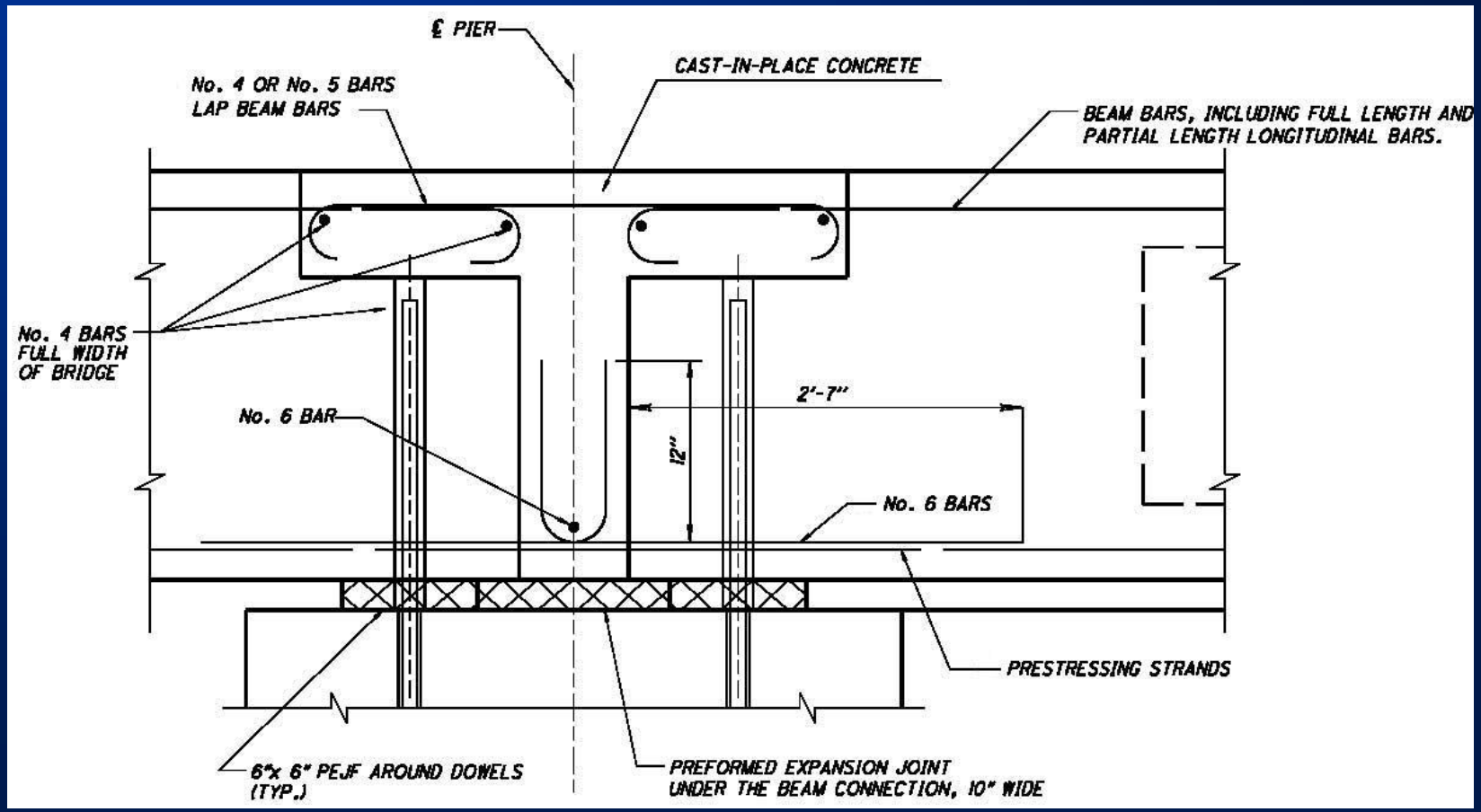
Composite Superstructure



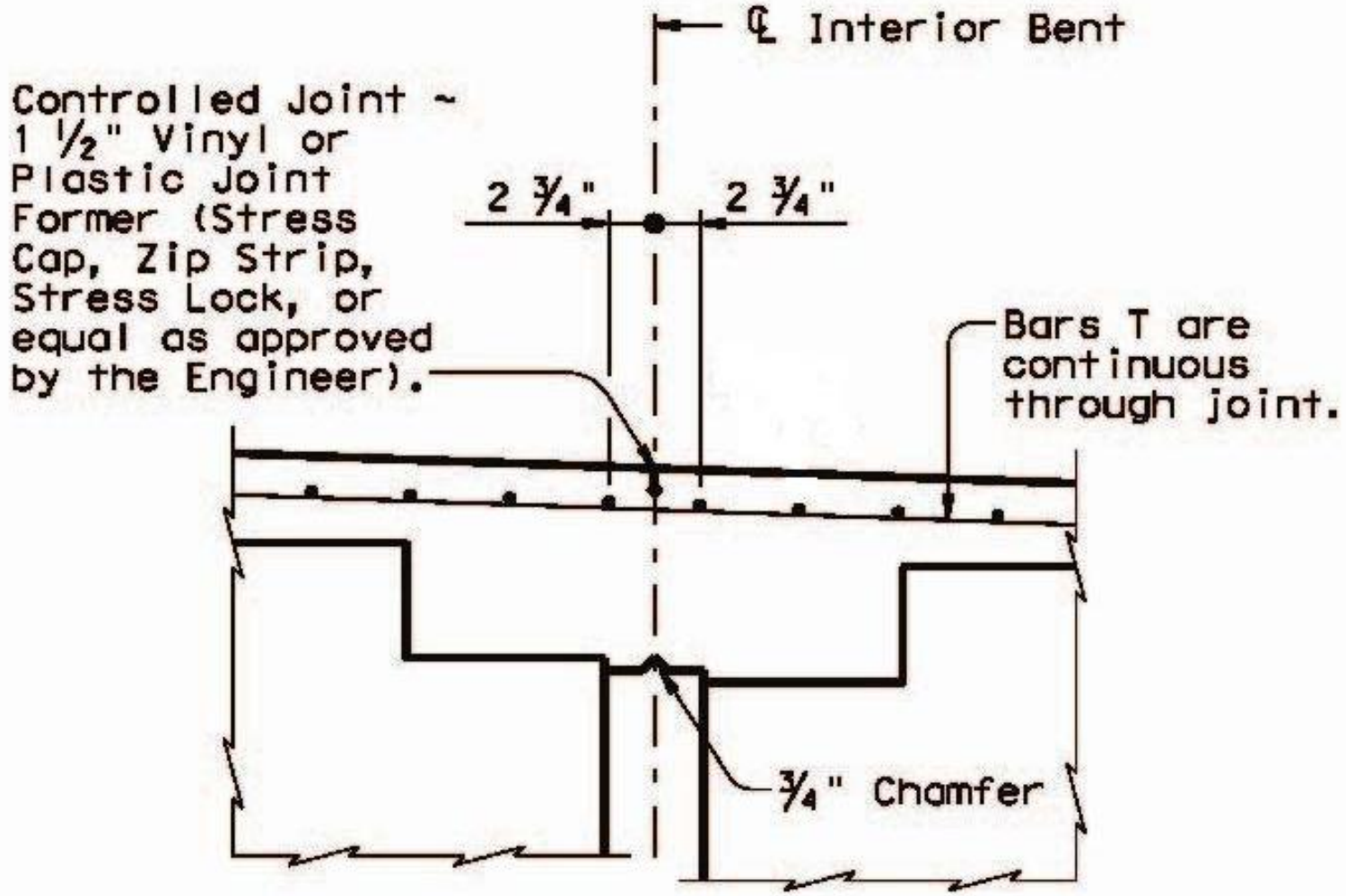
Composite Superstructure

Composite Superstructure

Continuity

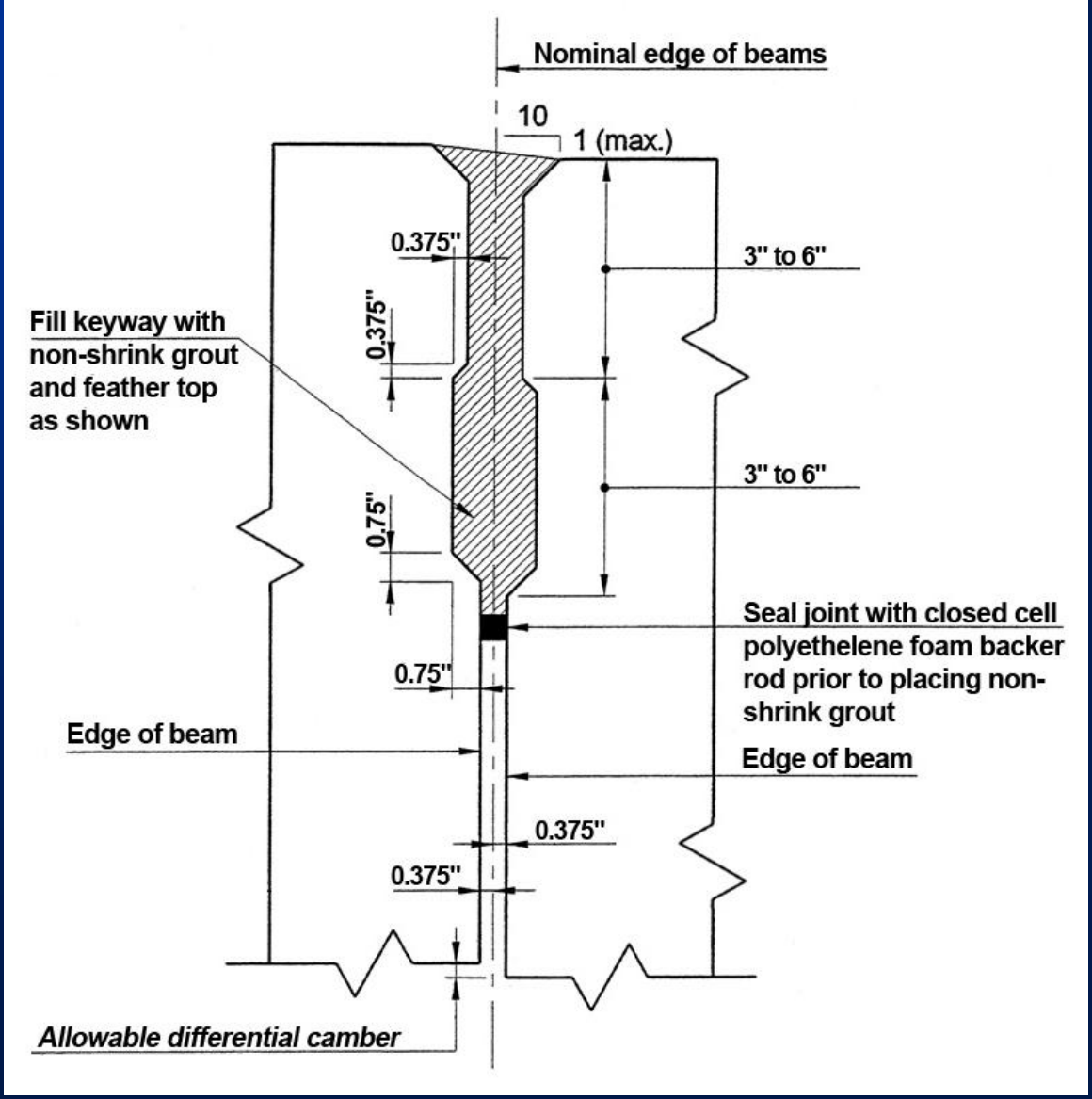

℄ PIER
CAST-IN-PLACE CONCRETE
No. 4 OR No. 5 BARS
LAP BEAM BARS
BEAM BARS, INCLUDING FULL LENGTH AND
PARTIAL LENGTH LONGITUDINAL BARS.
No. 4 BARS
FULL WIDTH
OF BRIDGE
No. 6 BAR
2'-7"
12"
No. 6 BARS
PRESTRESSING STRANDS
6"x 6" PEJF AROUND DOWELS
(TYP.)
PREFORMED EXPANSION JOINT
UNDER THE BEAM CONNECTION, 10" WIDE

Continuity

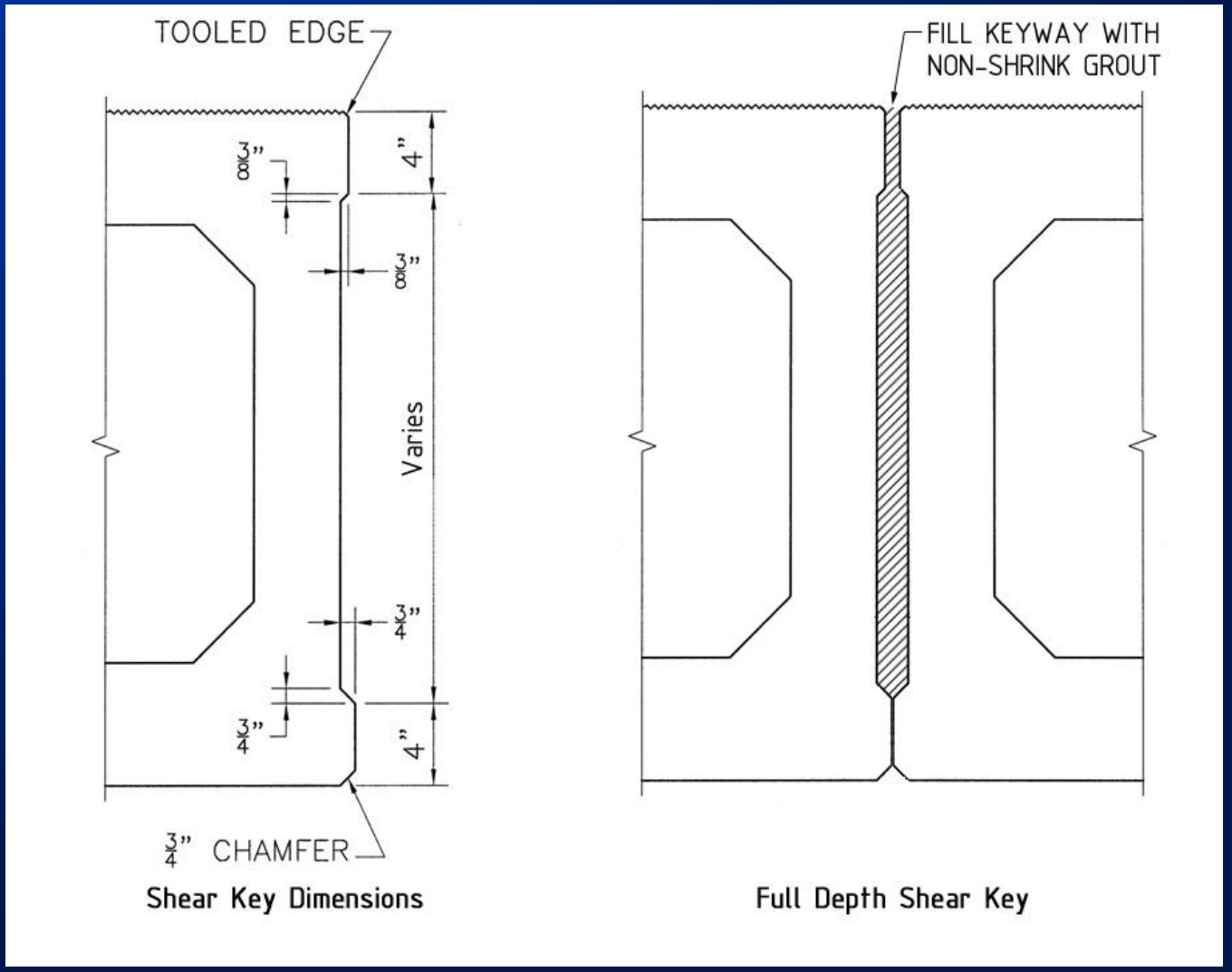

℄ Interior Bent
Controlled Joint ~ 1 ½" Vinyl or Plastic Joint Former (Stress Cap, Zip Strip, Stress Lock, or equal as approved by the Engineer).
2 ¾"
2 ¾"
Bars T are continuous through joint.
¾" Chamfer

Longitudinal Joints

Shear Key – Partial Depth



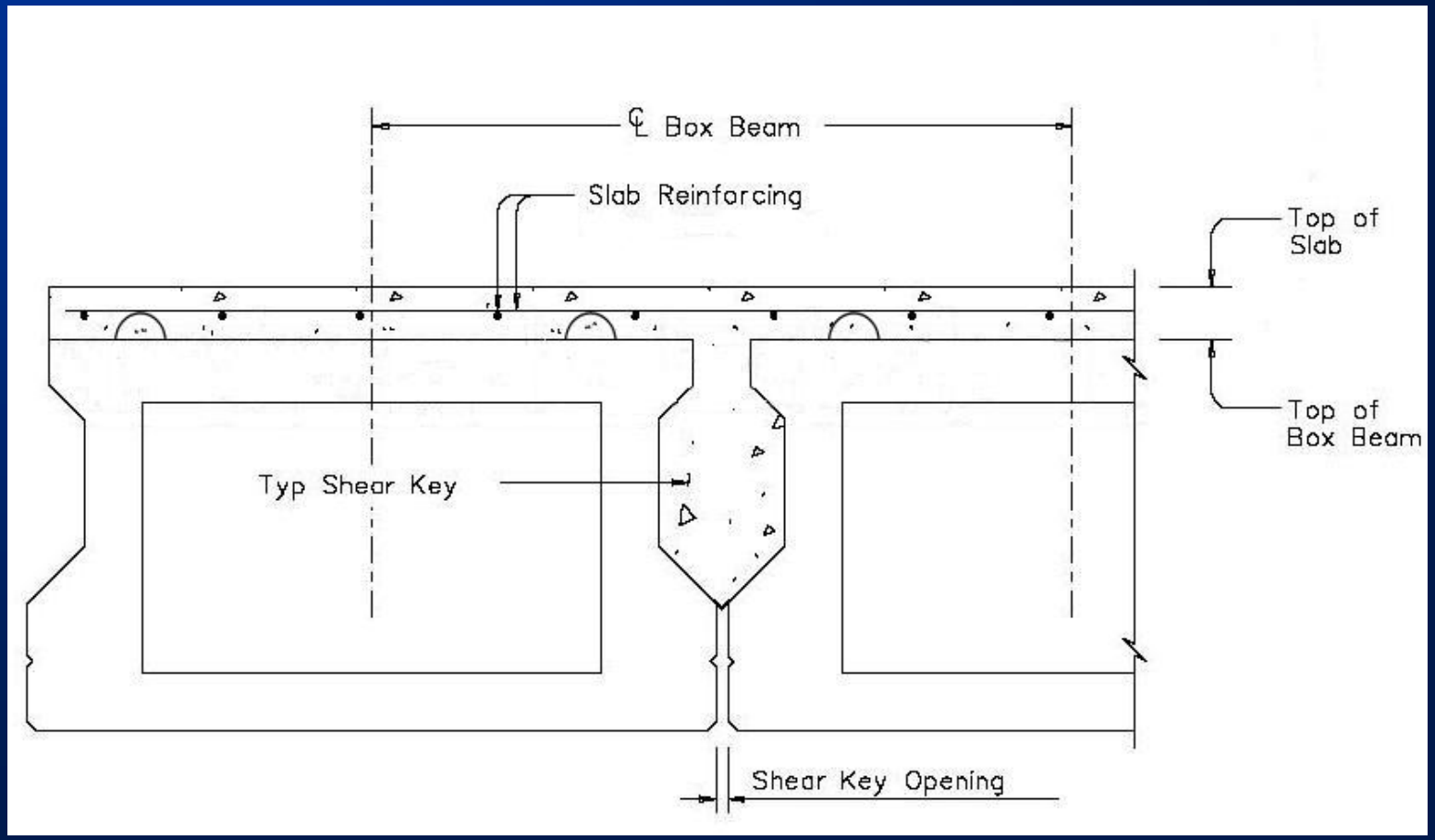
Shear Key – Full Depth



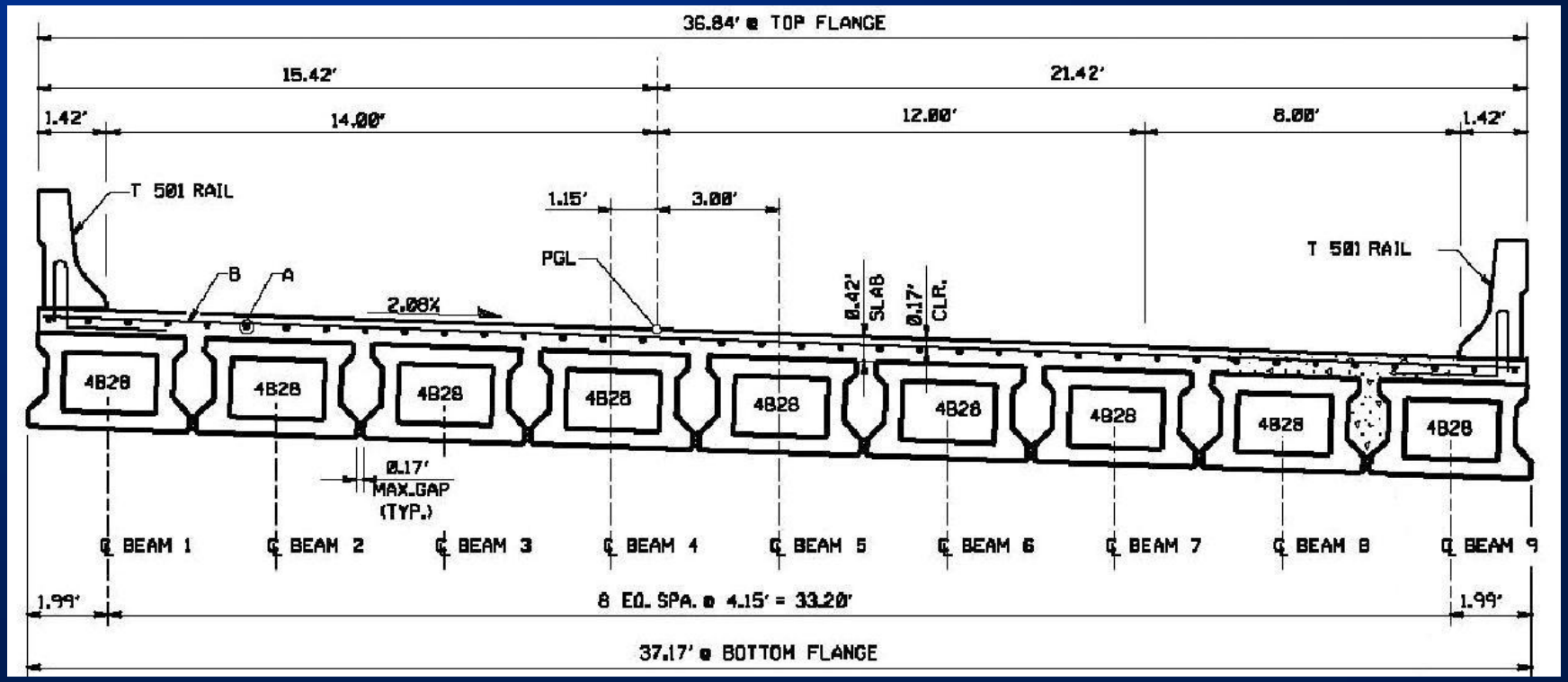
Shear Key Dimensions

Full Depth Shear Key

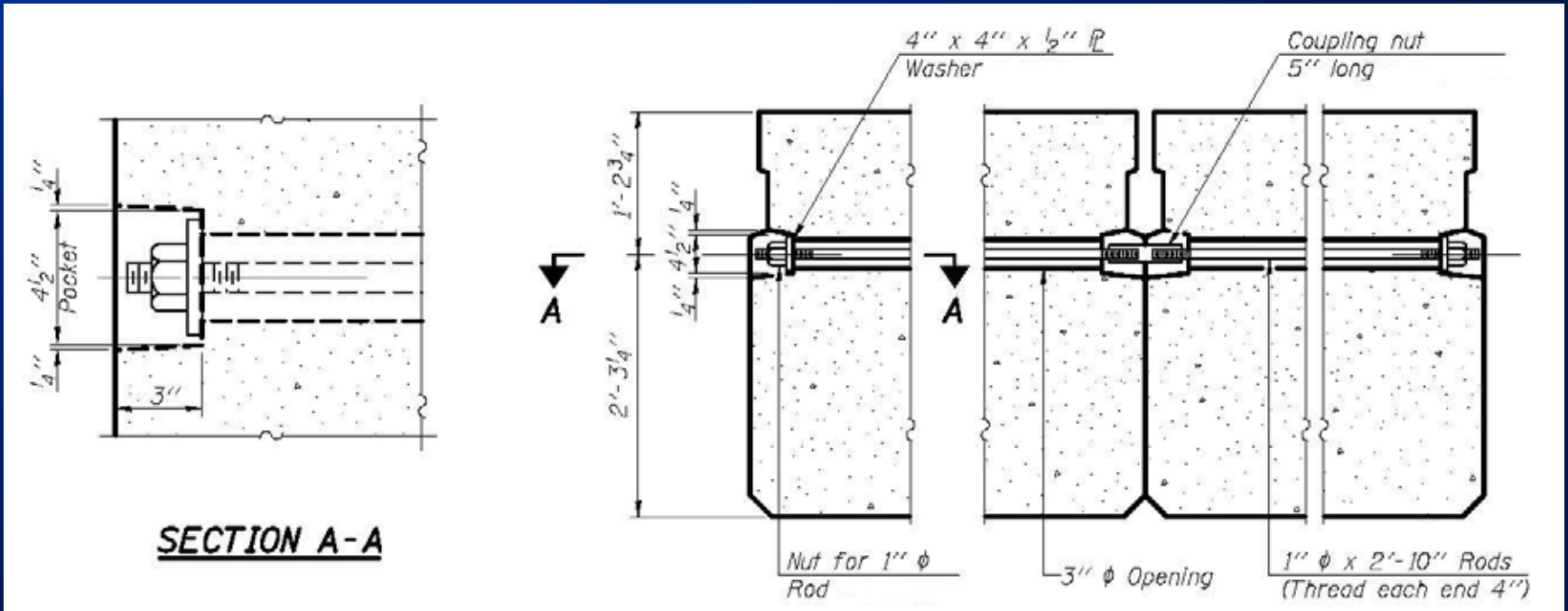
Shear Key - TxDOT



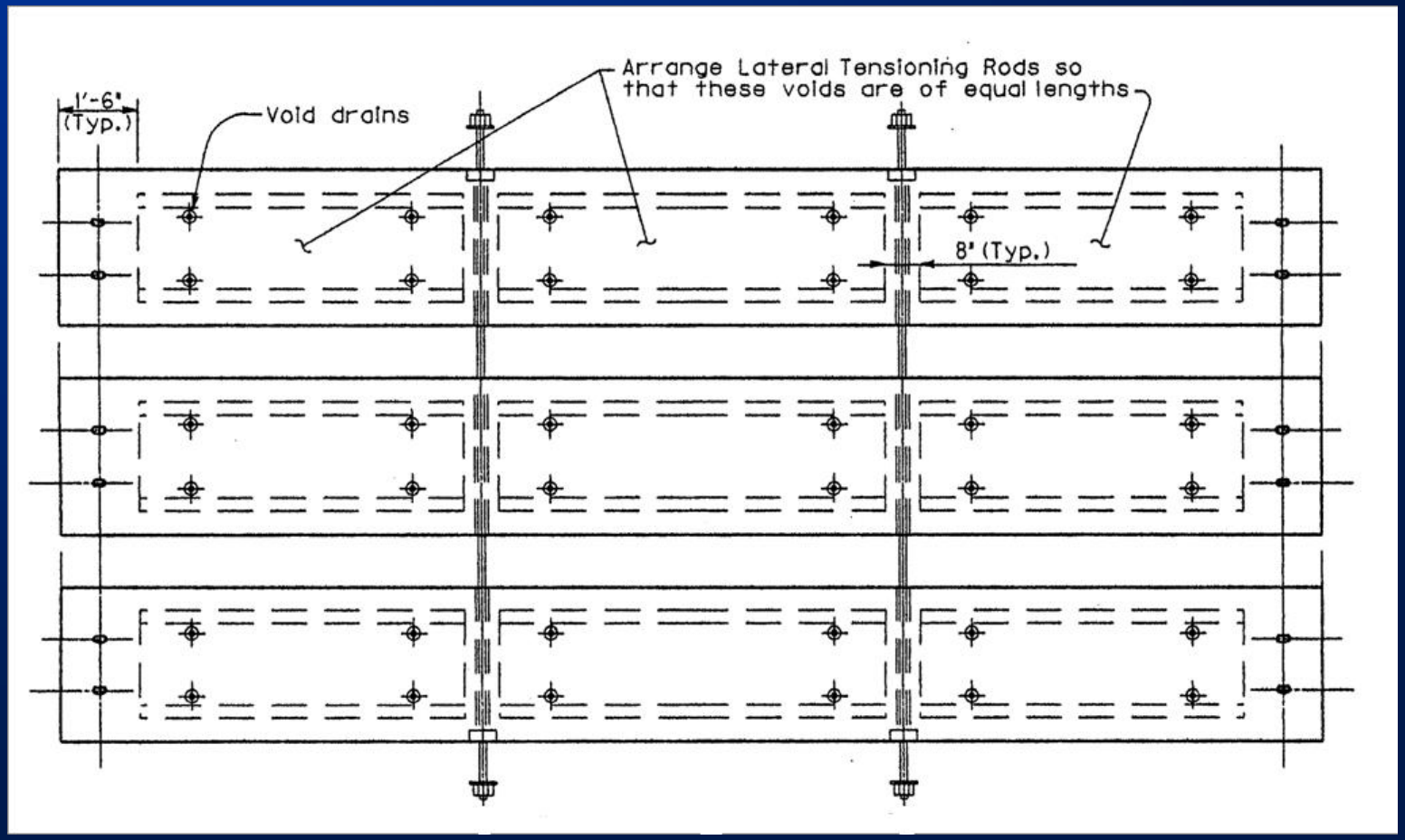
Shear Key - TxDOT



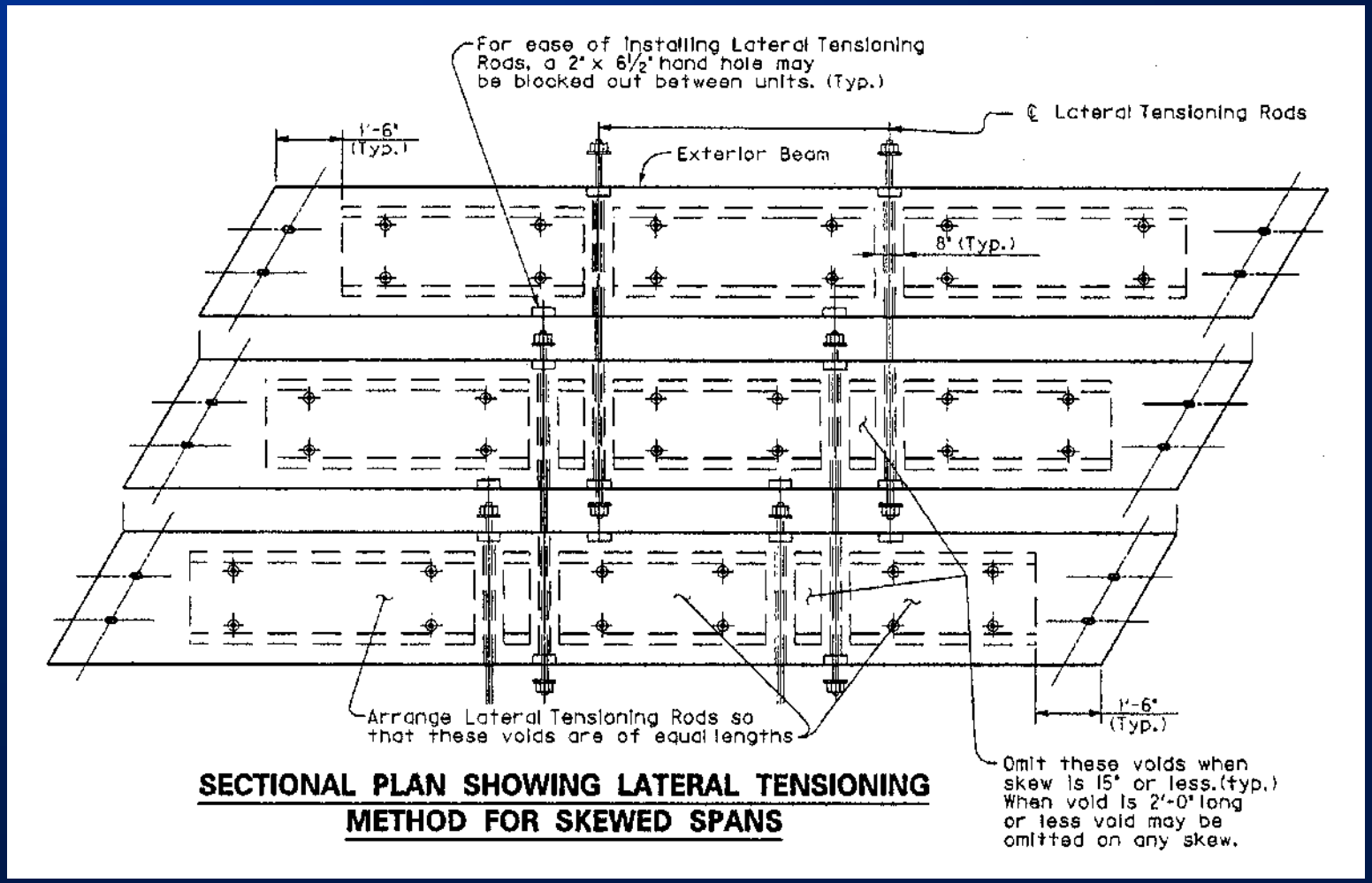
Transverse Tie Rods



Transverse Tie Rods



Transverse Tie Rods



SECTIONAL PLAN SHOWING LATERAL TENSIONING METHOD FOR SKEWED SPANS

Design

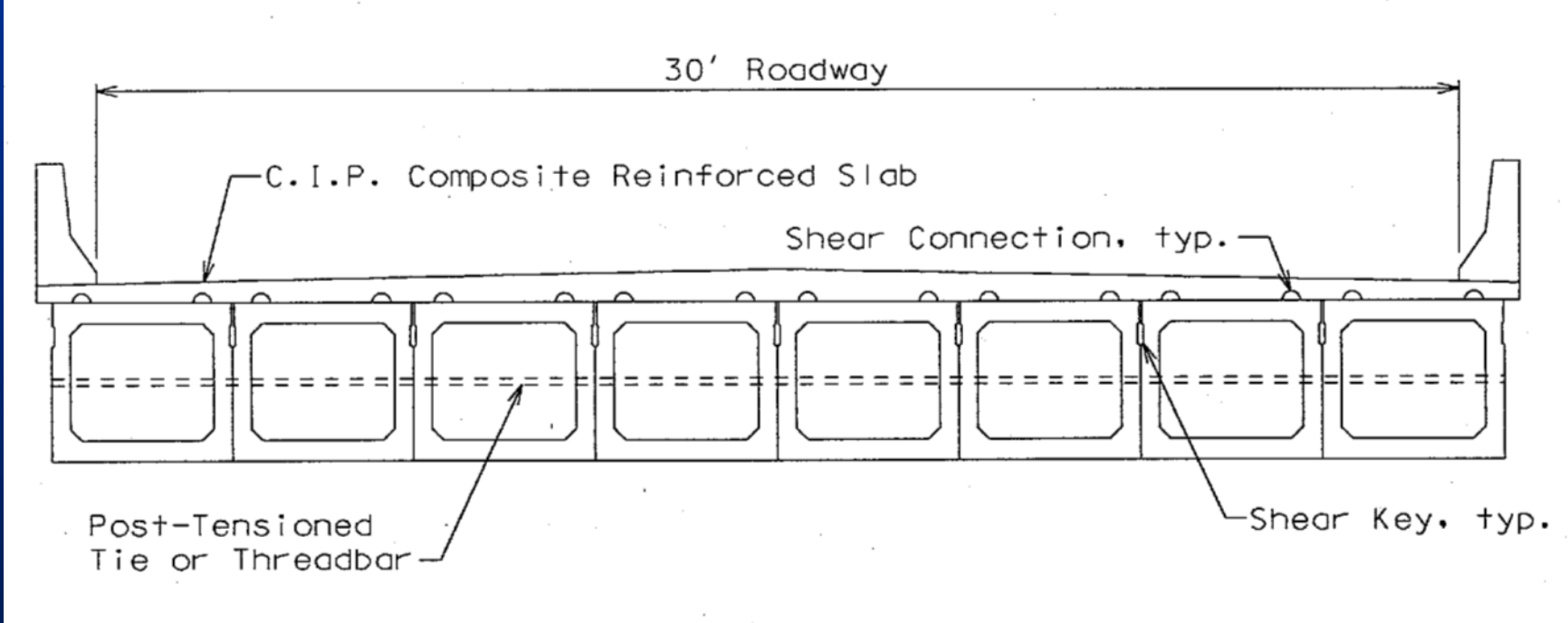
Design

Non-Composite

Vs.

Composite

Design


30' Roadway
C.I.P. Composite Reinforced Slab
Shear Connection, typ.
Post-Tensioned
Tie or Threadbar
Shear Key, typ.

Live Load Distribution per AASHTO LRFD

Structural Overlay

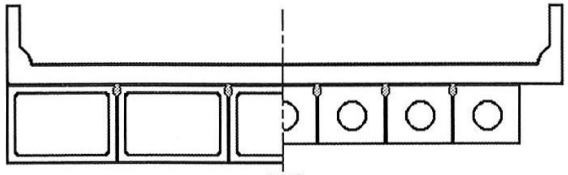
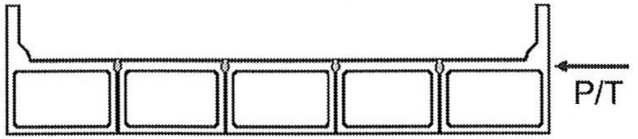
OR

"Sufficiently connected to act as a unit"

EQUALS

Better Distribution between Beams

Live Load Distribution per AASHTO LRFD

Supporting Components	Type of Deck	Typical Cross-Section
Precast Solid, Voided, or Cellular Concrete Boxes with Shear Keys	Cast-in-place concrete overlay	 (f)
Precast Solid, Voided, or Cellular Concrete Boxes with Shear Keys and with or without Transverse Post-Tensioning	Integral concrete	 (g)

Transverse Connection per AASHTO LRFD

Shear Transfer Joints

Vs.

Shear-Flexure Transfer Joints
"Sufficiently connected to act as a unit"

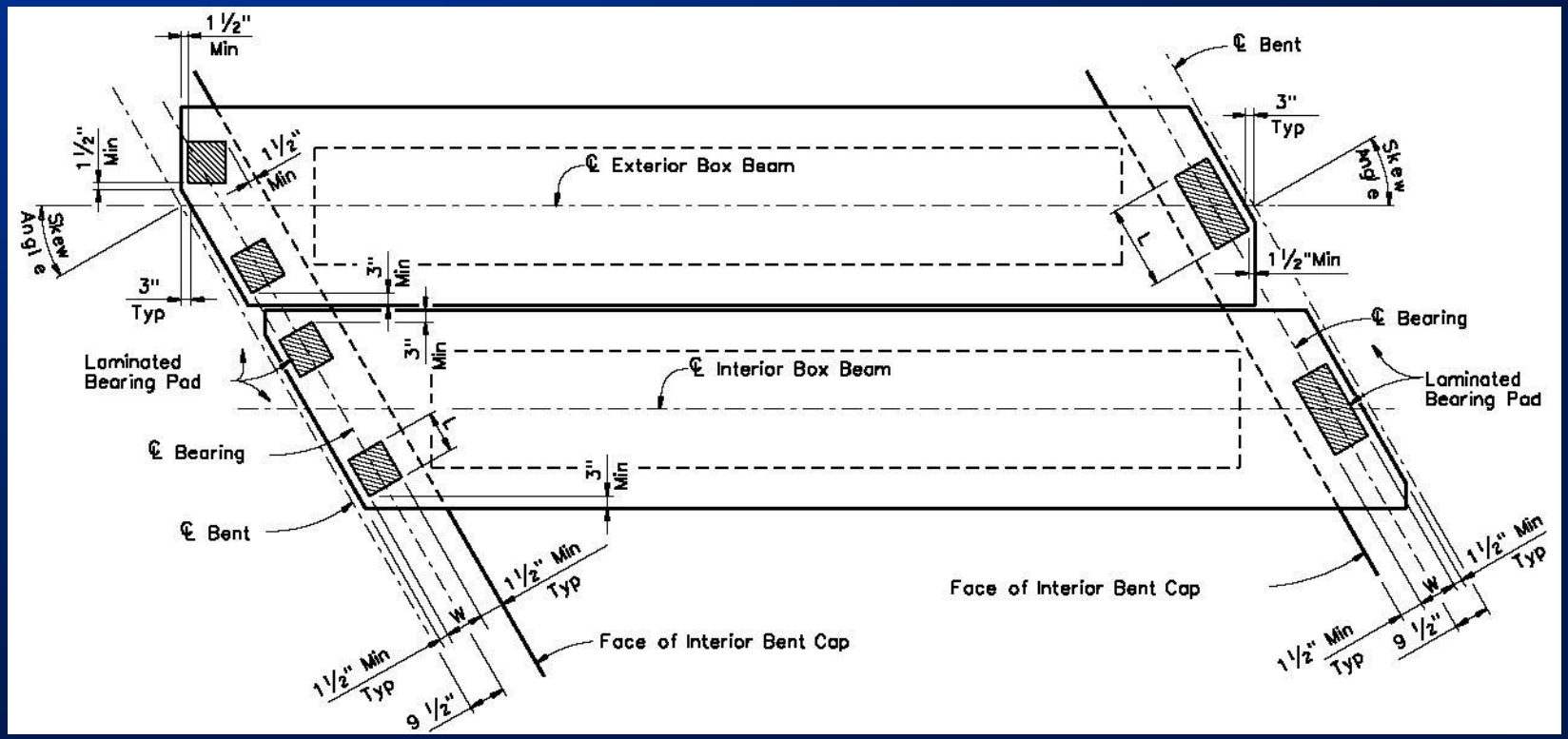
Transverse Connection per AASHTO LRFD

Transverse prestress amount determined by strip method or two-dimensional analysis

"…shall not be less than 0.25 ksi through the key."

Bearings

Bearings


1 ½" Min
℄ Bent
3" Typ
Skew Angle
1½" Min
℄ Exterior Box Beam
L
3" Min
1½"Min
℄ Bearing
Laminated Bearing Pad
℄ Interior Box Beam
Laminated Bearing Pad
℄ Bearing
r
℄ Bent
1½" Min Typ
W
Face of Interior Bent Cap
9 ½"

Inspection and Maintenance

Michigan Study

Michigan Study

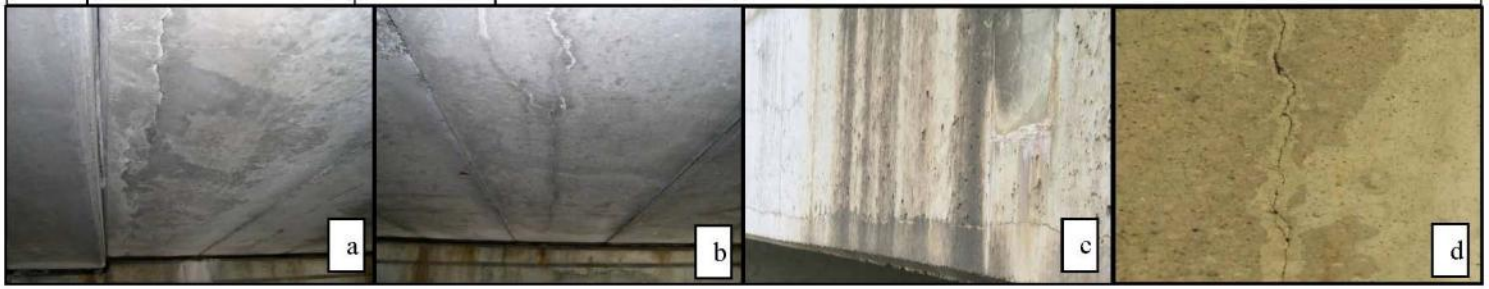
Michigan Study

Michigan Inspection Handbook

Box-Beam Rating	Condition Description
A	1. No cracks or staining
B	2. Map cracks 3. Hairline cracks
C	4. Spalling or delamination 5. Narrow cracks w/ water or corrosion 6. Water stains at joints 7. Longitudinal cracks on deck
D	8. Medium cracks w/o water 9. Evidence of displacement between beams
E	10. Medium cracks w/ water or corrosion
F	11. Wide cracks w/ water or corrosion
G	12. Spalling w/ exposed or corroded reinforcement 13. Shear or flexure cracking

Michigan Study

Item	Condition Description	Box-Beam Rating	Comments
8	Medium Cracks (0.01 to 0.03-in)	D	Record on assessment documentation and monitor during biennial assessments. Report length, width, location, and orientation of cracks. Perform load rating analysis.



Causes	Prevention	Engineering Effects	Repair Considerations
Structural Cracks: See Item 13, Causes (Page C-16). **Non-structural Cracks:** Temperature (exp/contraction) Thermal Gradient (solid/hollow section transition) Shrinkage (contraction at cure)	Proper production of box-beams can avoid cold joints or weak zones that result in longitudinal cracks (a, c). Shear stirrups must be placed transversely to prevent longitudinal cracks (b, d)	Medium cracks may pose little effect on the structural integrity of the member/structure. However, the location of these cracks can prove detrimental to the structure. Corner cracks have a potential to become long spalls. Cracks of 0.007 inch thickness mark the tolerance crack width where deicing chemicals are applied. Cracks wider than this pose concern of further degradation.	Crack should be repaired with a low-viscosity, crack penetrating sealant. A maintenance program should be established to monitor the crack growth and seal cracks.

Survey of Current Practice

Data Collection

SURVEY QUESTIONNAIRE

PRECAST PRESTRESSED BOX BEAM BRIDGES
(Both Spread and Abutting Box Beam Bridges)
For the
PCI COMMITTEE ON BRIDGES
SUBCOMMITTEE ON PRESTRESSED CONCRETE BOX BEAM BRIDGES

Area of Interest: Precast, prestressed (pre-tensioned and post-tensioned) concrete box beam bridges.

State/ Province: _____

A. General:

1. Does your agency use precast prestressed concrete box beam bridges? ☐ Yes ☐ No
   (If "No", please proceed to item G.3.)

2. Where have you used these types of beams?
   ☐ Highway bridges ☐ Railroad bridges ☐ Pedestrian bridges

3. What shape box do you use?
   ☐ AASHTO/PCI ☐ State standard ☐ Other
   (If "State standard", we ask that you please send a copy of the standard, see item G.2.)

4. Do you have skew angle limitations when using box beam bridges? ☐ Yes ☐ No
   If "Yes", what is the max. skew angle permitted? (acute angle measured from centerline of bridge to a line normal to pier/abutment) _____

5. Do you waterproof or coat the sides of the beam? ☐ Yes ☐ No
   If Yes, what do you use? _____

6. Does your agency have differential camber restrictions between adjacent beams? ☐ Yes ☐ No

7. How is differential camber dealt with?
   ☐ Grinding ☐ Temporary vertical jacking ☐ Overlay ☐ Other _____
   _____

8. How do you treat the strands at the ends of beams? ☐ Cut flush ☐ Burn flush ☐ Recess by melting with torch. Are recessed holes filled? ☐ Yes ☐ No If Yes, with what material? ____
   _____

9. Do you require that the ends of the beams be coated? ☐ Yes ☐ No
   How much of the ends? _____
   With what material? _____

B. Deck Slab & Overlay

1. Do you use this type of bridge with a composite, cast-in-place deck slab? ☐ Yes ☐ No
   If "yes", what is the usual thickness of the C.I.P. slab? _____

Data Collection

A. General
B. Deck Slabs and Overlays
C. Box Beam Construction
D. Keyways
E. Prestressing
F. Bearings
G. Experience

Questionnaire Response

SURVEY QUESTIONNAIRE RESPONSE
PRECAST PRESTRESSED BOX BEAM BRIDGES

Category	Item No.	Description	Alaska	Arizona	California
General	A.1	Use Box Beam Bridges?	yes	yes	yes
	A.2.	Location	Highway Bridges	Highway & Pedestrian Bridges	Highway, RR & Pedestrian Bridges
	A.3.	Shape of Box?	AASHTO/PCI & Other - Oregon DOT stnd	AASHTO/PCI	AASHTO/PCI, State standard & other
	A.4.	Any Skew Angle Limitation?	yes	yes	No
	A.4.1.	Max. Skew Angle Permitted?	30 degreees	30 degrees	-
	A.5.	Waterproof or Coat the Sides?	no	no	no
	A.6.	Any Differential Camber Restrictions?	yes	no	no
	A.7.	Differential Camber Corrective Action?	temporary vertical jacking	overlay	-
	A.8.	Any Treatment of Strands at Ends?	cut flush	cut flush	-
	A.8.1.	Are Recessed Holes Filled?	-	no	-
	A.8.2	If yes, with what material?	-	-	-
	A.9.	Are Ends of Beams Coated?	yes	no	no
	A.9.1	How much of the ends? Patch material over end of strands only?	around strand ends	-	-
	A.9.2	With what material? Unspecified waterproofing material?	zinc-rich paint	-	-
Deck Slab & Overlay	B.1.	Use with CIP Composite Deck Slab?	yes - sometimes	yes	yes
	B.1.1	Thickness of Slab?	4"	5"	7" to 8"

Case Studies Summary

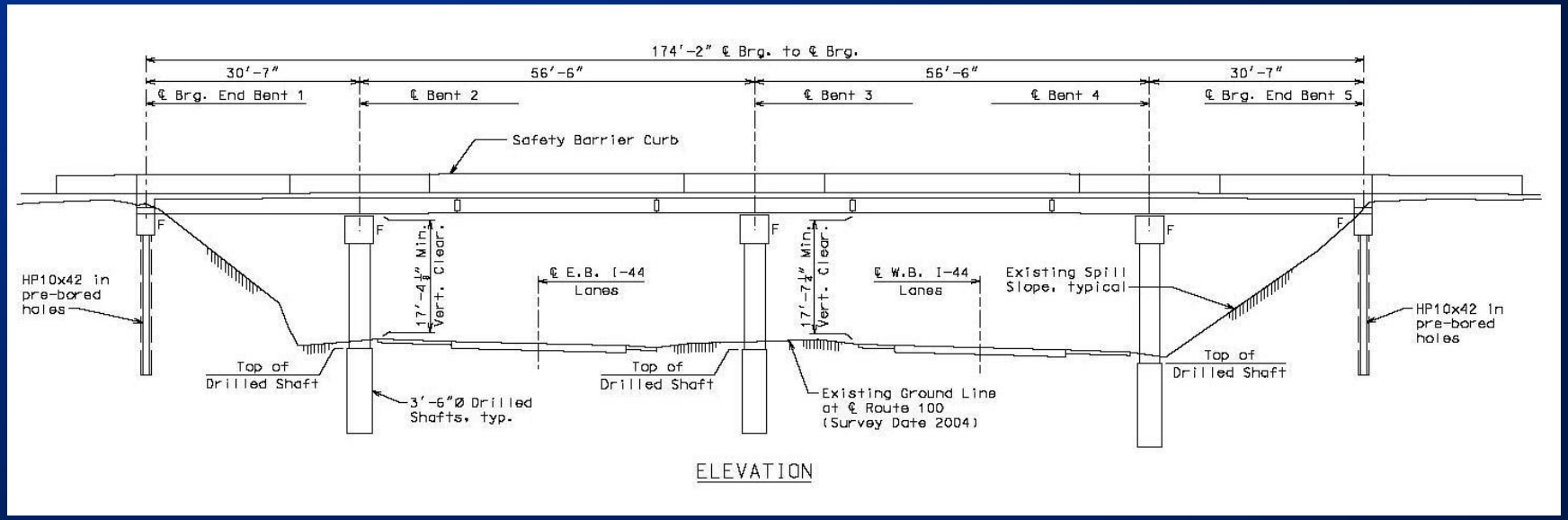
Case Studies

- TxDOT 9-Day Bridge
- Colorado Weekend Bridge
- Ohio 19-Day Box Girder Bridge
- BNSF Railway over Route 160, Springfield, MO
- MoDOT Route 100 over I-44, Gray Summit, MO

Route 100 over I-44

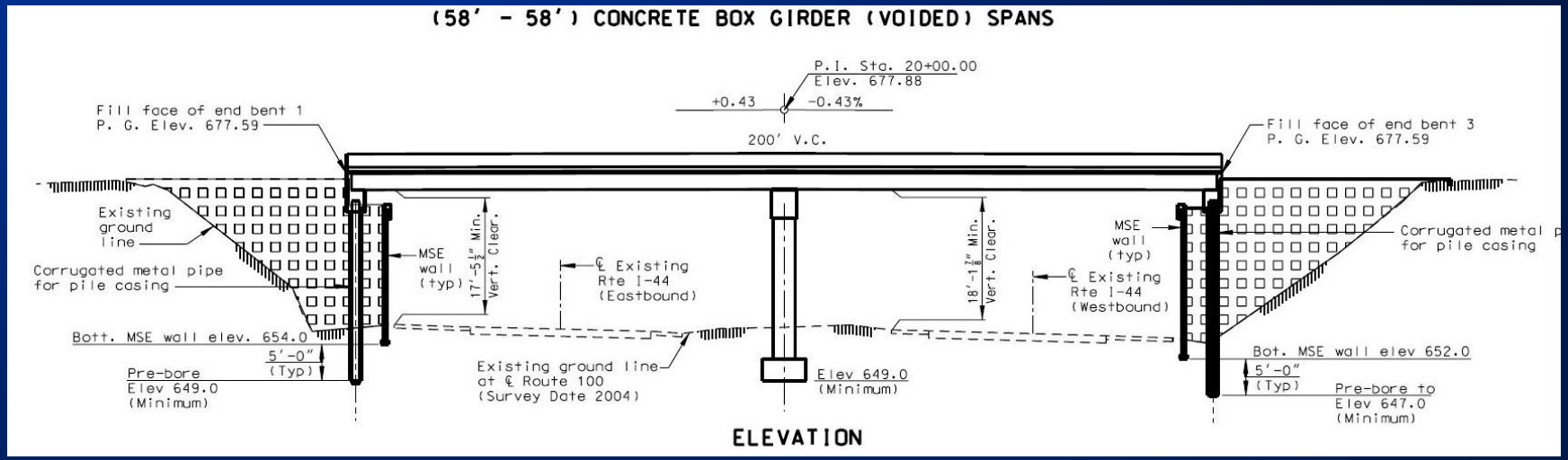
Original Bridge

Route 100 over I-44



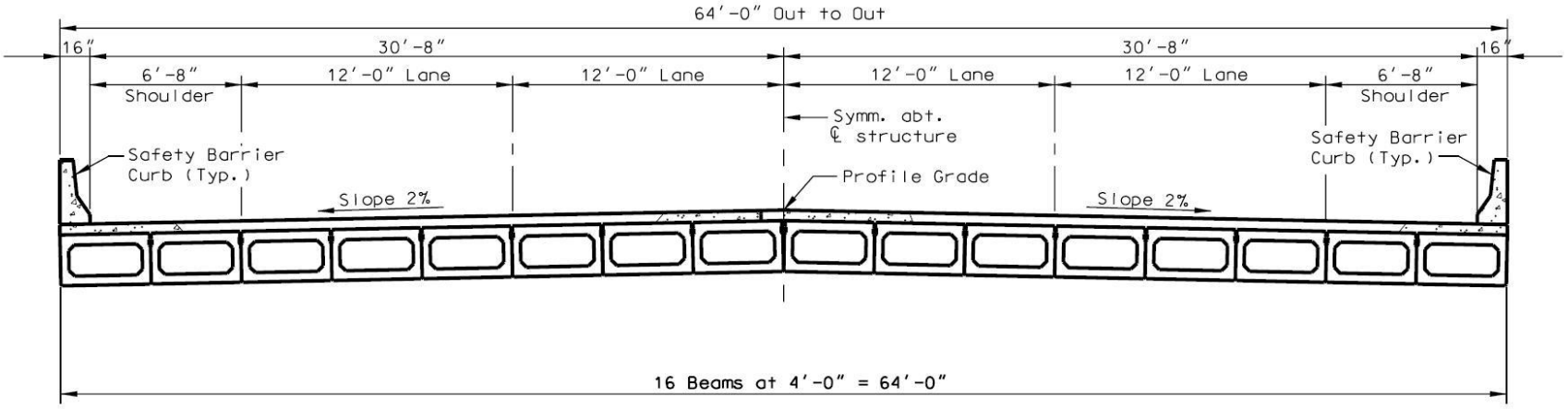
Original Steel Design Layout

Route 100 over I-44



VE Proposal – Adjacent Box Beams

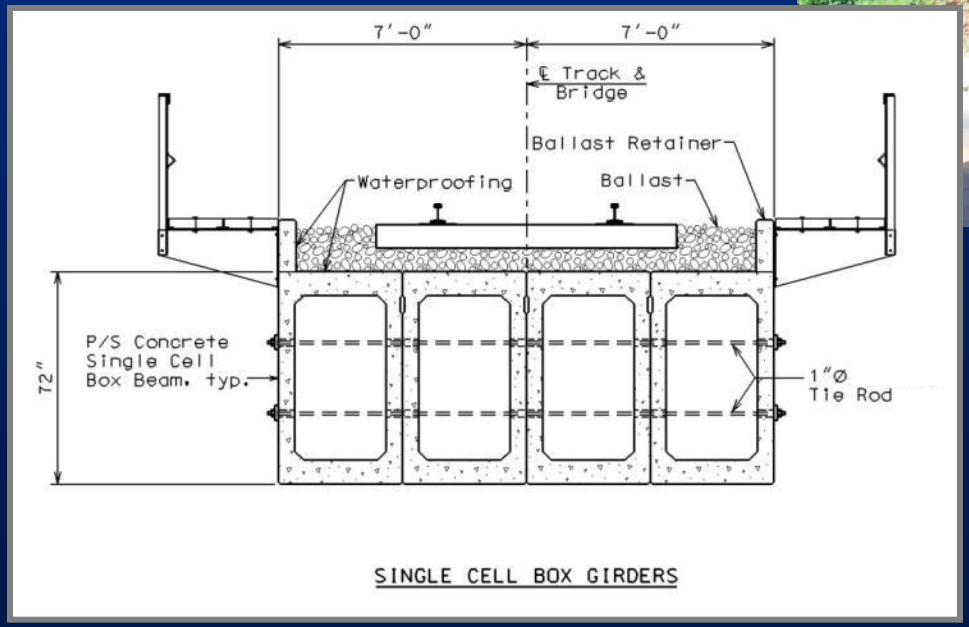
Route 100 over I-44



FINAL CROSS SECTION

BNSF over Route 160

BNSF over Route 160



Conclusions

Conclusions

- Minimize Longitudinal Cracking
  - Water Penetration
  - De-Icing Chemicals
- Ensure Long-Term Performance

Conclusions

Design

- Larger Shear Keys, Full Depth
- Increased Post-Tensioning Force
- Composite Reinforced Concrete Deck

Conclusions

Design

- Minimize Skew if Possible
- Three or Four Point Bearing System
- Increase Concrete Cover

Conclusions

Fabrication

- Use Polystyrene Forms for Voids
- Properly Anchor Voids
- Use of High Performance Concrete, Corrosion Inhibitors

Conclusions

Construction

- Sandblast Shear Keys Immediately Prior to Grouting
- Use Non-Shrink Epoxy Grout
- PT Layout and Sequence

HARRINGTON & CORTELYOU, INC.
A Burns & McDonnell Company